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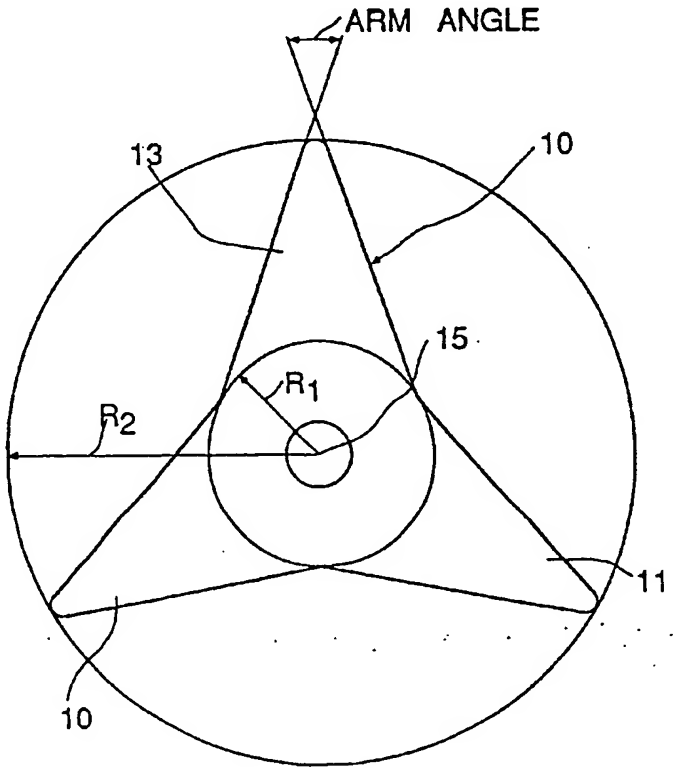
(54) Title: HOLLOW TRILOBAL CROSS SECTION FIBER

(57) Abstract

A trilobal synthetic polymeric thermoplastic fiber has a single void extending approximately axially central, a total cross-sectional void area between about 10 and 20 percent void, a modification ratio between about 2 and about 6, and an arm angle between about 5° and about 50°.



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Hollow trilobal cross-section fiber

Description

This invention relates generally to synthetic polymeric fibrous materials. More specifically, this invention relates to hollow trilobal cross-section fibers.

The term "fiber" as used herein includes fibers of extreme or indefinite length (i.e., filaments) and fibers of short length (i.e., staple). The term "yarn" as used herein means a continuous strand of fibers.

For many uses of fibrous synthetic polymers, it is desirable to minimize the weight of fiber needed to spread over an area. This qualitative property of a fiber is known as "cover". Another quality of fibers for certain end uses (like for carpet yarn) is the fiber's ability to hide soil. Additionally, it is important that contract carpets stand up to the severe wear these carpets get due to high traffic. Particularly important to contract carpeting are pile height recovery and appearance retention after wear traffic.

Trilobal fibers are known to provide cover superior to round cross-sections and it is known to make trilobal and pseudo-trilobal fibers (e.g., deltas, T-shapes). Exemplary are U.S. Patent No. 3,981,948 to Phillips, U.S. Patent No. 3,194,002 to Raynolds et al., U.S. Patent No. 2,939,201 to Holland, U.S. Patent No. 4,492,731 to Bankar et al. and Japanese Kokai 42-22574.

It is also known to provide voids in fibers and that many times these voids result in improved soiling hiding performance. However, lower void volumes (less than about 10%) can result in carpeting with a high streak potential. U.S. Patent No. 3,745,061 to Champaneria et al. and U.S. Patent No. 4,407,889 to Gintis et al. show non-round fibers having one or more voids.

It is known also to provide trilobal or pseudo-trilobal fibers which have one or more voids. Exemplary are U.S. Patent No. 3,095,258 to Scott, U.S. Patent No. 3,357,048 to Cobb, Jr., U.S. Patent No. 3,493,459 to McIntosh et al., U.S. Patent No. 3,558,420 Opfell, U.S. Patent No. 4,279,053 to Payne et al., U.S. Patent No. 4,364,996 to Sugiyama, U.S. Patent No. 4,956,237 to Samuelson and British Patent No. 843,179 to Siemer et al.

U.S. Patent No. 4,648,830 to Peterson et al. discloses a spinneret for manufacturing hollow trilobal cross-section fibers. The fibers disclosed therein have one axially extending hole in each lobe.

To address the foregoing deficiencies, the present invention concerns a trilobal synthetic polymeric thermoplastic fiber having a single void extending approximately axially central, a total cross-section void area between greater than about 10 and 20 percent void, a modification ratio between about 2 and about 6, and an arm angle between about 5° and about 50°.

It is an object of the present invention to provide an improved hollow trilobal fiber.

Related objects and advantages will be apparent to the ordinarily skilled artisan after reading the following detailed description of the invention.

Fig. 1 is a cross-sectional plan view of a fiber according to the present invention.

Fig. 2 is a plan view of a spinneret useful to prepare the fiber of Fig. 1.

The term "modification ratio" (MR) means the ratio of the radius R_2 of the circumscribed circle to the radius R_1 of the inscribed circle as shown in Fig. 1. The term "arm angle" (AA) is the angle formed by extension of sides of an arm as shown in Fig. 1.

Depicted in Fig. 1 is an enlarged view of fiber 10 which is representative of the present invention. Fiber 10 is trilobal having three (3) lobes, 11, 12 and 13 and axially extending, more or less central, void 15.

According to the present invention, fiber 10 preferably has a modification ratio of between about 2 to about 6, more preferably about 2.0 to about 3.5 and an arm-angle between about 5° and about 50°, preferably from 7° to 40°. The single approximately central void represents greater than about 10 to about 20 percent, preferably 11 to 20 percent, in particular 12-20 and particularly preferably 12 to 15 percent, of the total fiber volume measured including the volume of the void.

Fig. 2 illustrates a spinneret useful for preparing the fiber of the present invention.

Fibers of the present invention may be prepared from synthetic thermoplastic polymers which are melt spinnable. Exemplary polymers are polyamides such as poly(hexamethylene adipamide), polycaprolactam and polyamides of bis(4-aminocyclohexyl)methane and linear aliphatic dicarboxylic acids containing 9, 10 and 12 carbon atoms; copolyamides; polyester such as poly(ethylene)terephthalate and copolymers thereof; and polyolefins such as polyethylene and polypropylene. Both heterogeneous and homogeneous mixtures of such polymers may also be used.

As is apparent to one ordinarily skilled in the art, the fibers can be prepared by known methods of spinning fibers. Molten polymer is spun through spinneret orifices shaped to provide the desired void volume and fiber cross-sections under spinning conditions which give the desired denier. Specific spinning conditions and spinneret orifices, shapes and dimensions will vary depending upon the particular polymer and fiber product being spun.

To achieve the desired percent void, the spinning and quenching conditions are modified appropriately. For example, the percent void can generally be increased by more rapid quenching of the molten fibers or by increasing the polymer melt viscosity.

As demonstrated by the Examples and Table below, the present invention provides a carpet fiber having low streak potential without sacrificing wear qualities.

Test Methods

Percent Void:

The void-to-fiber ratio for hollow fibers is obtained by measuring the size of the hole within the fiber and comparing it to the size of the fiber as if no hole existed. This comparison is performed via computer analysis of the image of a fiber as projected on a television-type monitor. Before an image analysis is performed, the yarn must be dyed. If the yarn provided is bright or semi-dull, it is dyed with a disperse green stock solution, but the color is not particularly important. When the yarn must be dyed, it is placed in 400 ml of water with 50 ml of disperse green stock solution and 50 ml of disperse green additives and heated to approximately 95°C. A section of the sample approximately 7 inches long is placed into the solution for five minutes, then removed, washed with cold water, and dried.

In the following examples, a Leitz TAS Plus Image Analyzer and associated equipment is used and operated according to the instructions. The analyzer integrates void area and total cross-sectional area. The ratio of these two integrals times 100 equals percent void.

Arm Angle

Fiber cross sections are magnified (200X) to determine the arm angle. Two tangent straight lines are drawn for each arm and the angle formed from the two straight lines is measured. The reported arm angle represents the average of ten measurements.

Streak Potential

Streak potential is evaluated by visual comparison. Results are reported as vivid streaking , moderate streaking or essentially streak free.

Pile Height Recovery

Static Compression

Static compression testing is performed using a standard static compression aparatus with air pressure adjusted to 50 psi (351,000 Pa). Four and 1/2 inch (11.4 cm) diameter samples are placed under the legs of the compression apparatus and 50 psi (351,000 Pa) of air pressure is applied by lowering the legs. The legs remain on the samples for 24 hours. Results are reported as the percent of original pile height retained after the load is removed.

Vetterman Drum

Vetterman drum testing is done with a metal drum having an internal diameter of 730 mm, an internal depth of 270 mm, an effective depth of 240 mm, and a thickness of the curved surfaces of 8 mm. This drum is used at a speed of 16 revolutions per minute, and the direction of rotation is reversed every five minutes with approximately a one second stationary time between changes of direction. The revolutions of the drum are counted, and specimens are held in place by adjustable retaining segments. Loose pile fibers are continuously extracted by a vacuum cleaner. Inside the drum, a round steel ball is situated. The steel ball is 120 mm in diameter and weighs 6800 grams. The ball is fitted with 14 rubber

studs located to b equally spaced on the ball's surface (118 mm apart).

Four specimens, 570 mm long in the direction of manufacture and 265 mm wide, are cut, and a similarly sized and positioned specimen is cut for comparison purposes. The samples are placed into the drum and held securely with the retaining segments. The revolution counter is set for 22,000 cycles. After all cycles are complete, the specimens are cleaned with the vacuum cleaner, making four forward and backward passes along the length, ensuring that all of the area is covered, and that the final pass is in the direction of the pile lay. The specimens are allowed to lie flat pile side up for at least 24 hours before comparison with the control. Results are reported as percent of original pile height retained after 22,000 revolutions.

Tetrapod

Tetrapod wear testing is performed according to ASTM standard method D5251-92 using 500,000 revolutions. Results are reported as the percent of original pile height retained after 500,000 revolutions.

All relative viscosities given in the examples are determined as 1 g/100 ml solution in 96 wt.% H_2SO_4 and measured at 25°C.

Example 1

A spinneret having 440 filament capillaries arranged rectangularly in 7 rows and 62 to 64 capillaries per row is used to make hollow trilobal fibers. The capillaries are formed generally according to Fig. 2 with appropriate design for the desired arm angle, percent void and modification ratio and are offset with respect to the capillaries of each next adjacent row.

Nylon 6 polymer (Relative Viscosity measured in H_2SO_4 = 2.7) is extruded with conventional spinning conditions into a quench stack and taken up onto packages and then further processed by drawing, crimping and cutting into typical 20 denier per filament staple carpet fiber. The staple fiber is spun via conventional known methods into spun, plied heatset carpet yarn. The melt temperature is 265°C. Throughout is 1000 gm/min. Quench flow is 200 ft./min (60.8 m/min). The draw ratio is 3.0.

The carpet yarn is then tufted into a primary backing using conventional tufting methods to make 1/8 gauge (3.17 mm), 11.3 stitches per inch (4.45 stitches/cm) carpet having a pile

height of 0.375 inch (0.95 cm) and a pile weight of 40 ounces per square yard (1.35 kg/m^2). Samples of this carpet are evaluated for percent void, arm angle, streak potential, and pile height recovery. The results are reported in the Table.

Example 2 (Comparative)

A spinneret has 440 filament capillaries arranged rectangularly in 7 rows and 62 to 64 capillaries per row. The capillaries are formed to make a hollow trilobal fiber within the scope of U.S. Pat. 5,208,107 (= EP 516 119) with appropriate design for the desired arm angle, percent void and modification ratio. The capillaries are offset with respect to the capillaries of each next adjacent row.

Nylon 6 polymer (Relative Viscosity measured in H_2SO_4 = 2.7) is extruded with conventional spinning conditions into a quench stack and taken up onto packages and then further processed by drawing, crimping and cutting into typical 20 denier per filament staple carpet fiber. The staple fiber is spun via conventional known methods into spun, plied heatset carpet yarn. The melt temperature is 265°C. Throughput is 1000 gm/min. Quench flow is 200 ft./min (60.8 m/min). The draw ratio is 3.0.

The carpet yarn is then tufted into a primary backing using conventional tufting methods to make 1/8 gauge (3.17 mm), 11.3 stitches per inch carpet (4.45 stitches/cm) having a pile height of 0.375" (0.95 cm) and a pile weight of 40 ounces per square yard (1.35 kg/m^2). Samples of this carpet are evaluated for percent void, arm angle, streak potential, and pile height recovery. The results are presented in the Table.

Example 3 (Comparative)

A spinneret has 440 filament capillaries arranged rectangularly in 7 rows and 62 to 64 capillaries per row. The capillaries are formed to make solid trilobal fibers with the modification ratio set out in the Table. The capillaries are offset with respect to the capillaries of each next adjacent row.

Nylon 6 polymer (Relative Viscosity measured in H_2SO_4 = 7) is extruded with conventional spinning conditions into a quench stack and taken up onto packages and then further processed by drawing, crimping and cutting into typical 20 denier per filament staple carpet fiber. The staple fiber is spun via conventional known methods into spun, plied heatset carpet yarn. The melt

temperature is 265°C. Throughput is 1000 gm/min. Quench flow is 200 ft./min (60.8 m/min). The draw ratio is 3.0.

The carpet yarn is then tufted into a primary backing using conventional tufting methods to make 1/8 gauge (3.17 mm), 11.3 stitches per inch (4.45 stitches/cm) carpet having a pile height of 0.375" (0.95 cm) and a pile weight of 40 ounces per square yard (1.35 kg/m^2). Samples of this carpet are evaluated for percent void, streak potential and pile height recovery.

Example 4 (Comparative)

A spinneret having 440 filament capillaries arranged rectangularly in 7 rows and 62 to 64 capillaries per row. The capillaries are formed to provide arm angle and modification ratio set forth in the Table. The capillaries are offset with respect to the capillaries of each next adjacent row.

Nylon 6 polymer (Relative Viscosity measured in H_2SO_4 = 2.7) is extruded with conventional spinning conditions into a quench stack and taken up onto packages and then further processed by drawing, crimping and cutting into typical 20 denier per filament staple carpet fiber. The staple fiber is spun via conventional known methods into spun, plied heatset carpet yarn. The melt temperature is 265°C. Throughput is 1000 gm/min. Quench flow is 200 ft./min (60.8 m/min). The draw ratio is 3.0.

The carpet yarn is then tufted into a primary backing using conventional tufting methods to make 1/8 gauge (3.17 mm), 11.3 stitches per inch (4.45 stitches/cm) carpet having a pile height of 0.375" (0.95 cm) and a pile weight of 40 ounces per square yard (1.35 kg/m^2). Samples of this carpet are evaluated for percent void, streak potential and pile height recovery. The results are reported in the Table.

Table

						Pile height recovery		
Example No.	MR	Arm Angle	Denier/ Filament	Void (%)	Streak Potential	Static Compression	Vetterman Drum	Tetrapod
1	2.5	15-30°	20	14	Streak-Free	96%	83%	80%
2	2.7	30-40°	20	6	Moderate Streaking	94%	88%	86%
3	2.2		20	0	Moderate Streaking	96%	86%	86%
4	3.0	17-20°	20	0	Moderate Streaking	95%	85%	83%

Claims

1. A trilobal synthetic polymeric thermoplastic fiber having a single void extending approximately axially central, a total cross-sectional void area between greater than about 10 and 20 percent void, a modification ratio between about 2 and about 6, and an arm angle between about 5° and about 50°.

2. The fiber of claim 1 wherein the total cross-sectional void area is from 12 to 20 percent void.

3. The fiber of any of claims 1 to 2 wherein the modification ratio is between about 2 and about 3.5.

4. The fiber of any of claims 1 to 3 wherein the arm angle is between about 10° and 35°.

5. The fiber of any of claims 1 to 4 wherein the modification ratio is between about 11 and 15.

6. A carpet made from fibers according to any of claims 1 to 5.

Drawings

FIG.1

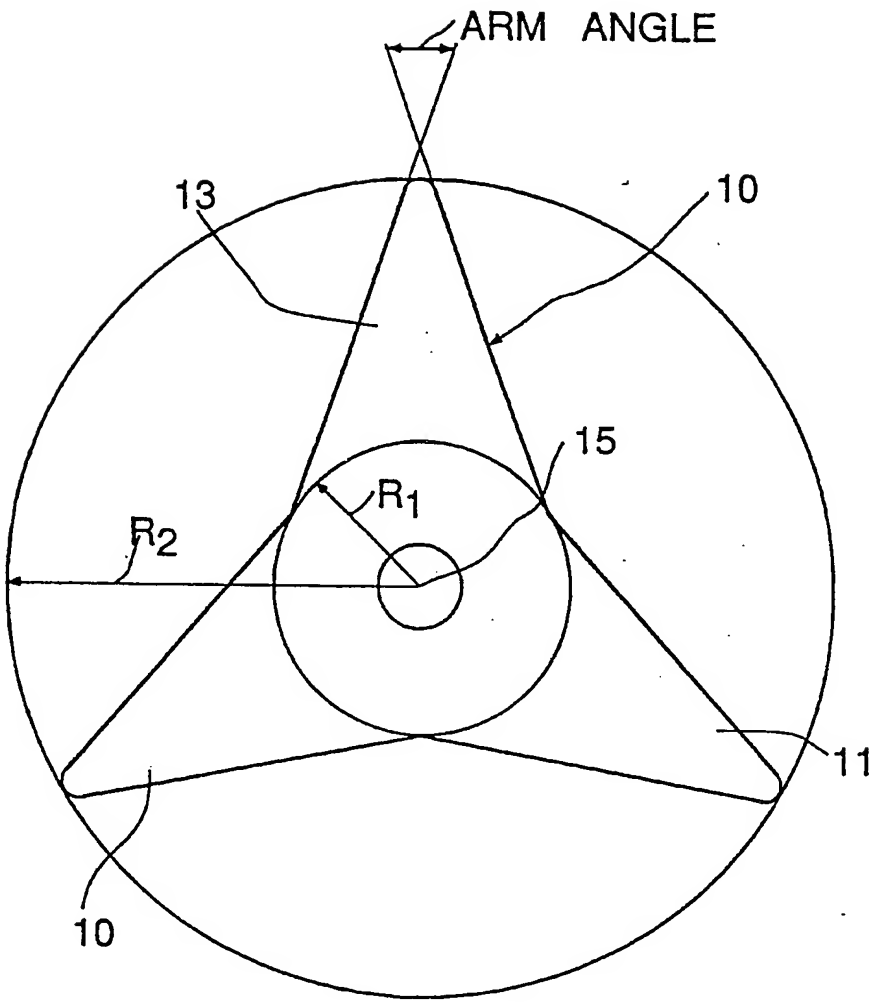
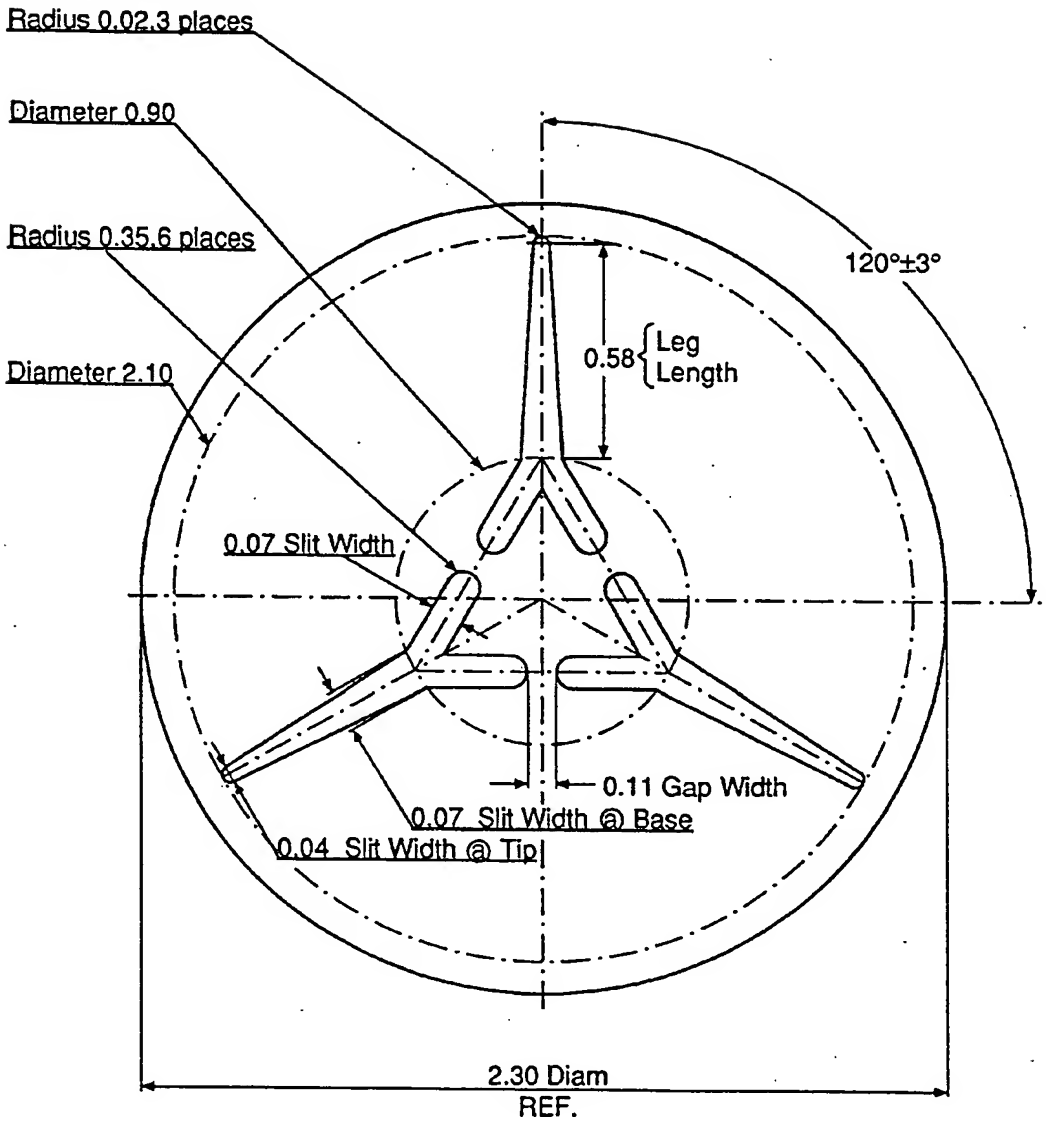


FIG.2



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INTERNATIONAL SEARCH REPORT

In tional Application No
PCT/EP 93/03375

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 D01D5/24 D01D5/253

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 D01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	JP,A,5 287 632 (TORAY INDUSTRIES, INC.) 2 November 1993 see the whole document & DATABASE WPI Section Ch, Week 9348, Derwent Publications Ltd., London, GB; Class F, AN 93-383606 see abstract	1-6
Y	EP,A,0 516 119 (BASF CORPORATION) 2 December 1992 cited in the application see the whole document	1-6
Y	US,A,3 405 424 (ULRICH IMOBERSTEG ET AL.) 15 October 1968 see column 2, line 9 - line 46	1-6

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,4 492 731 (VILAS G. BANKAR ET AL.) 8 January 1985 cited in the application see the whole document	1-6
Y	JP,A,59 036 714 (TEIJIN KK) 29 February 1984 see figures & PATENT ABSTRACTS OF JAPAN vol. 8, no. 126 (C-228)13 June 1984 see abstract	1-4,6
A	GB,A,1 160 263 (IMPERIAL CHEMICAL INDUSTRIES LIMITED) 6 August 1969 see claim 7; figures IIA,IIB	1-6

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Int ional Application No
PCT/EP 93/03375

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
JP-A-5287632		NONE		
EP-A-0516119	02-12-92	US-A-	5208107	04-05-93
		JP-A-	4361607	15-12-92
		JP-A-	4361606	15-12-92
US-A-3405424		NONE		
US-A-4492731	08-01-85	CA-A-	1208899	05-08-86
		JP-A-	59094609	31-05-84
JP-A-59036714	29-02-84	NONE		
GB-A-1160263	06-08-69	NONE		